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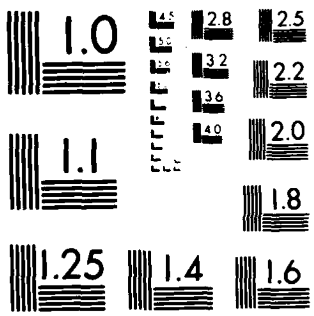

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EVALUATION OF THE EPOXY SYSTEM FOR THE REPAIR OF FUEL TANK M109

ROBERT E. SACHER, LAI M. CHOW, and JAMES M. SLOAN
POLYMER RESEARCH DIVISION

September 1983

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ABSTRACT

The repair time to completely process and repair the fuel tank NSN 2910-00-937-9539, M109, has been found to take approximately 36 hours. Production Engineering requires a more productive method of repair, especially the time factor. Infrared analysis was utilized to optimize the repair time to yield a well-cured epoxy repair system. It was found that room temperature curing takes an indefinite time to cure. A temperature of 83°C is the minimum temperature required for a reasonably cured system and 121°C is the temperature required for complete cure.

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INTRODUCTION

Army items such as laminated fiberglass fuel tanks and aluminum radiators utilize an epoxy resin system as part of the repair kit. The following information is provided with the repair of the fuel tank NSN 2910-00-937-9539, M109.

a. DMWR 9-2350-217/1, p. 4-75 through 4-76.4
b. TM 9-2350-217-34/1, p. 63-65
c. Drawing no. 10954382
d. Instruction Booklet, "Open Epoxy Plastic Repair Kit 2910-078-4065 (10941900)," p. 4-76.

Therefore, there are four possible sets of instructions to follow as repair procedures. The main problem is that it takes approximately 36 hours to completely process and repair the fuel tanks. Production Engineering believes that a much more productive method of repair, especially a drastic reduction of the time of repair, be utilized, and thus, commenced a study on optimizing the repair procedure.

The repair system which is used is similar in composition to those used in the original construction. The epoxy system utilized is 16486 epoxy resin (8073-0430) and is supplied by the Con-Tite Rubber Corp., Inwood, New York 11696. The epoxy resin was found to be a diglycidyl ether of bisphenol-A type of epoxy. The 16486 hardener (8073-0431) system is also supplied by the Con-Tite Rubber Corp.

These substances were cured under a number of different conditions in order to optimize the time of repair without hindering the quality of the repair system.

EXPERIMENTAL

The instructions for the repair procedure were followed according to ordinance Part No. 10941900. One hundred parts of epoxy were combined with 15 parts of hardener and then mixed. Thin films of the epoxy/hardener were placed on a potassium-bromide salt plate and cured in a thermostatted oven. At various sampling intervals the plate was placed in the sample compartment of a Digilab Model FTS-10M Fourier Transform Infrared Spectrometer. Each spectrum consisted of 120 co-added interferometric scans at 4 cm^{-1} resolution. The following conditions were monitored to evaluate the extent of cure and therefore the quality of the repair system.

1. An initial infrared scan was taken immediately after the film deposition.
2. Samples were then cured at room temperature (25°C + 2°C = 77°F + 4°F), 43°C (109°F), 53°C (127°F), 63°C (145°F), 83°C (181°F) and 121°C (250°F). Infrared spectra were measured every 30 minutes on the thin films with the exception of the 121°C cure; the 121°C system was evaluated by infrared spectroscopy at 15 minute intervals.

RESULTS

The resin system is predominantly a diglycidyl ether of bisphenol-A (DGEBA) (Figure 1). The DGEBA system appears to be somewhat advanced (strong OH at 3500 cm^{-1} due to the opening of oxirane rings). At least one other component is contained in the liquid epoxy resin system.

The hardener system is identified as a very complex polyamino (3200 cm^{-1} and 3320 cm^{-1} NH_2 bonds) mixture containing aromatic (1595 cm^{-1} and 1505 cm^{-1} phenyl C=C bonds) and aliphatic (2960 cm^{-1} to 2820 cm^{-1}) C-H stretching frequencies (Figure 2). When the two are mixed using the 100 parts of epoxy to 15 parts of hardener ratio, the only distinct frequencies from the amine hardener are the 3360 cm^{-1} and 3300 cm^{-1} bonds (Figure 3).

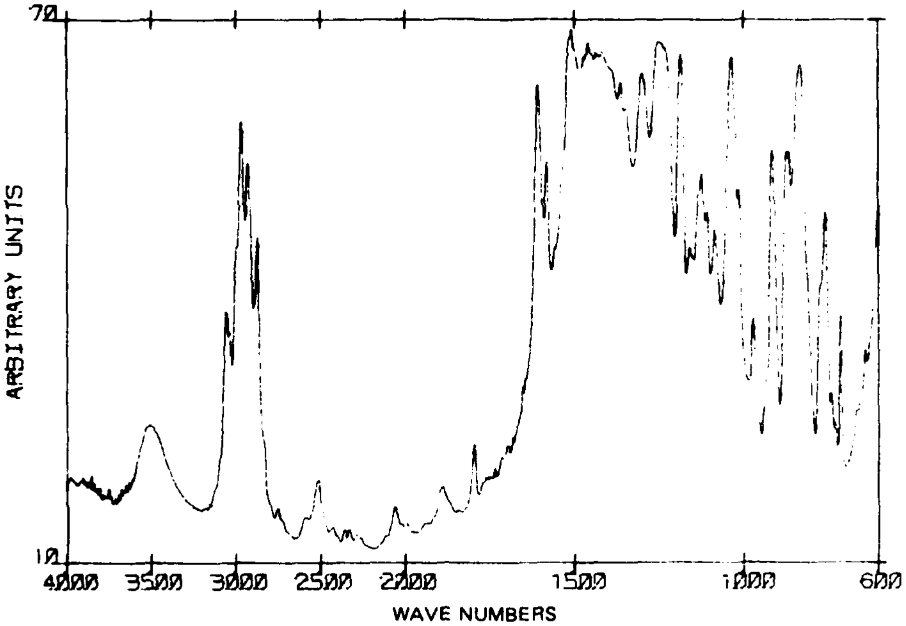

Figure 1. 16486 epoxy resin system.

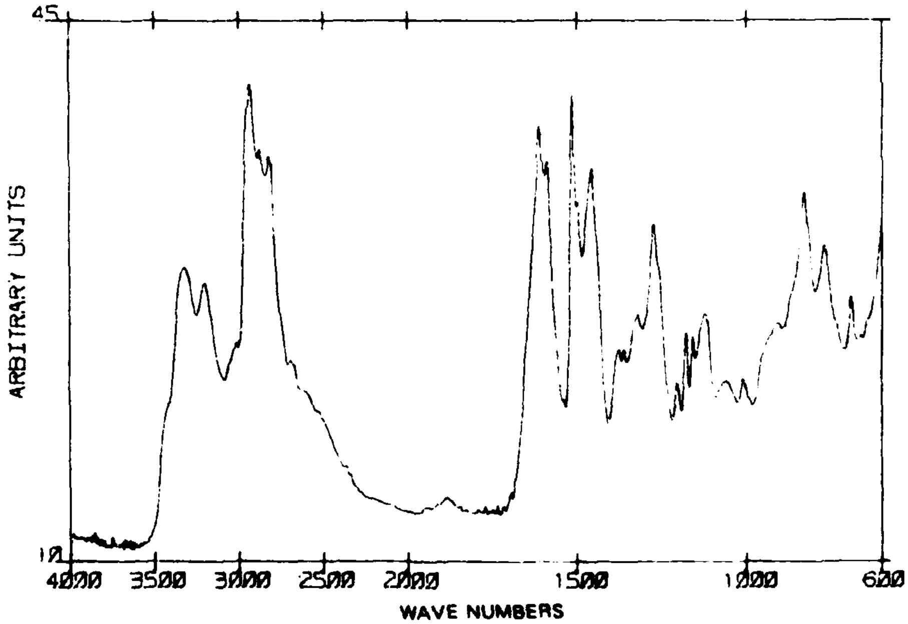

Figure 2. 16686 hardener system.

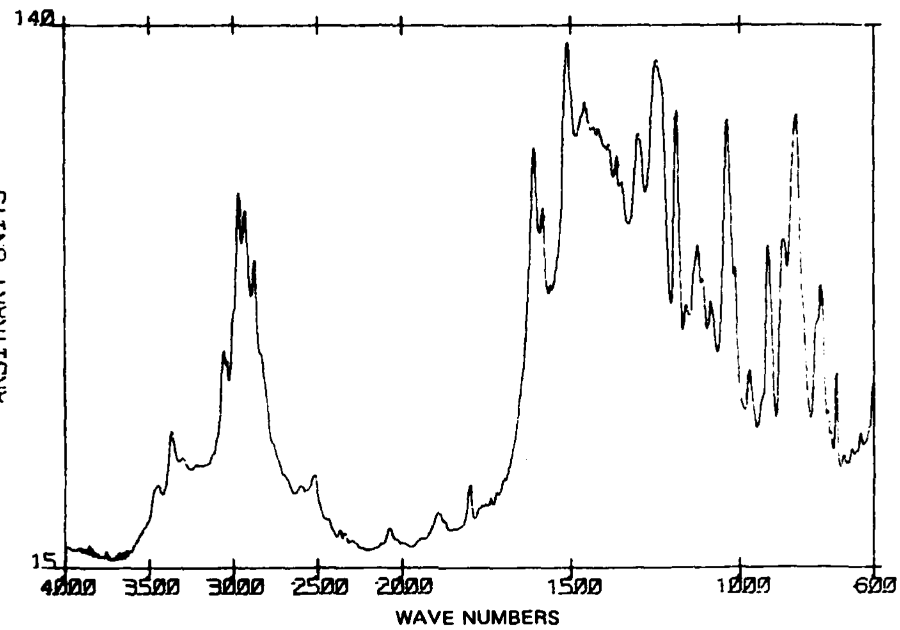

Figure 3. Epoxy resin/hardener starting mixture.

The extent of cure or the repair time is followed by the loss of the exoxy group at 917 cm^{-1} compared to a phenyl C=C absorption at 1510 cm^{-1} which is insensitive to the chemical changes occurring in the curing mechanism. The results are illustrated in Figure 4.

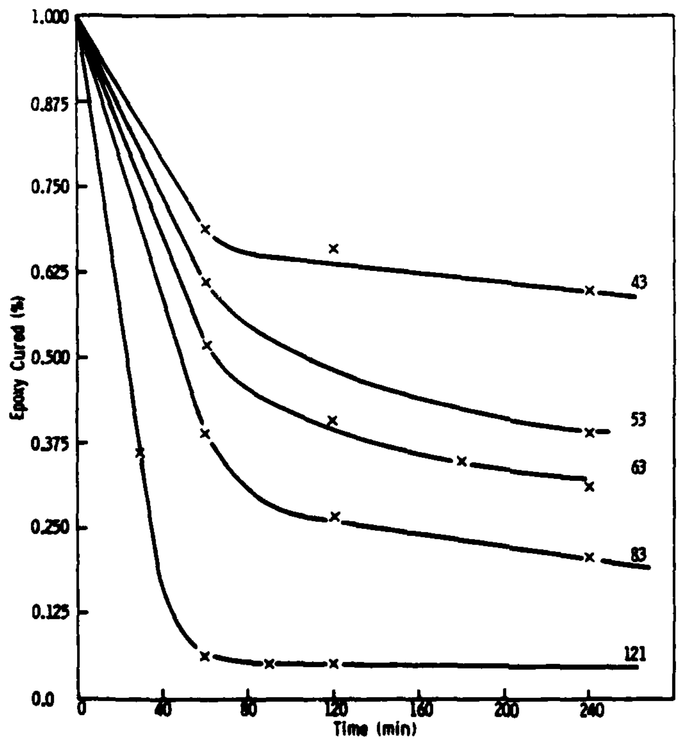

Figure 4. Epoxy cure conversion.

The results illustrate that heating at 121°C for one hour yields a fully reacted epoxy system (Figure 5). At 83°C, the system is about 75% cured after two hours (Figure 6). For the systems cured at 63°C, 53°C, and 43°C respectively, approximately 35%, 40%, and 60% of the epoxy groups have not reacted after four hours. After twenty-four hours of curing, very little change is detected in the extent of cure. At the latter three temperatures, it would appear to take several days before an efficiently-cured repair system would be achieved.

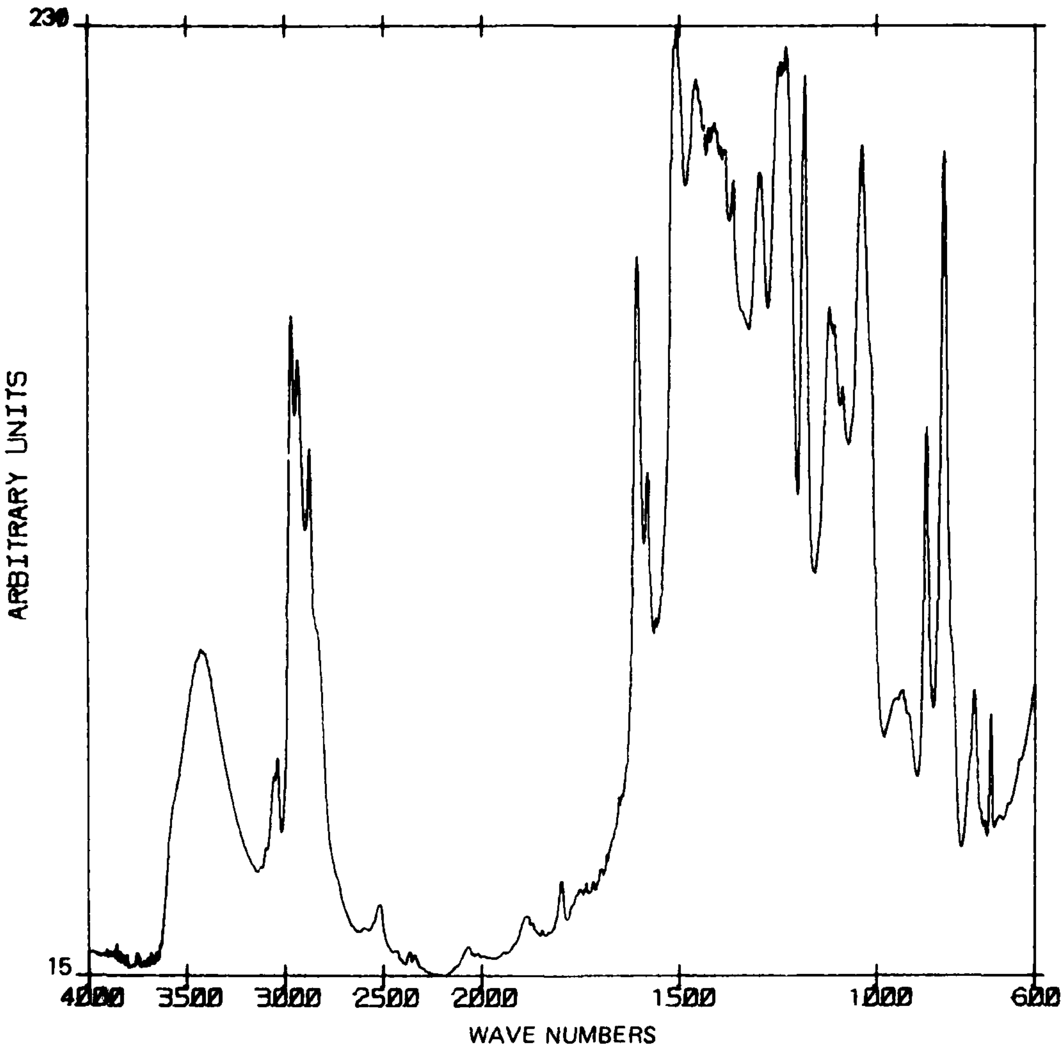

Figure 5. Infrared spectrum of epoxy resin/hardener cured at 121°C.

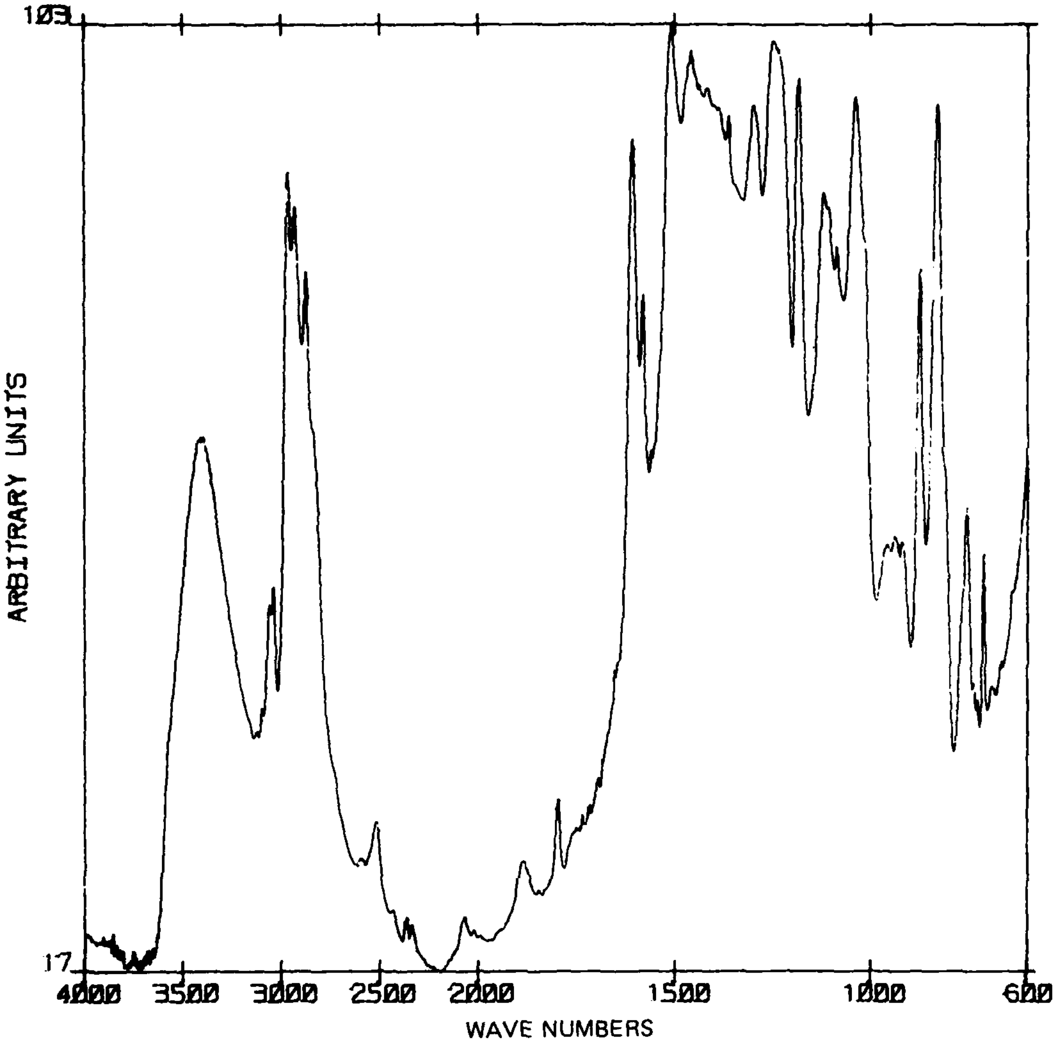

Figure 6. Infrared spectrum of epoxy resin/hardener cured at 83°C.

CONCLUSION

It appears that the minimum temperature for producing a good repair system is 83°C. Any temperature below 83°C appears to yield an epoxy system with a considerable amount of unreacted epoxy groups, thus limiting the physical performance of the hardened material. In conclusion, infrared analysis would be an excellent quality control procedure for the classification of good and poor repair systems and as a check on the consistency of the epoxy-based starting materials.

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